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THE IMPACT OF LOW CALORIC FEEDING DURING EXERCISE.(U)
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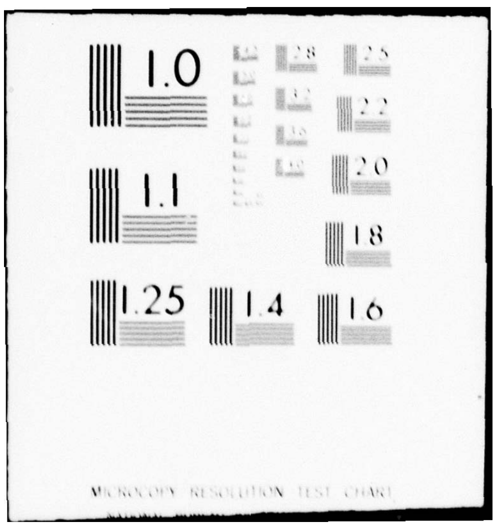
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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER LAIR Reprint 76-102	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) THE IMPACT OF LOW CALORIC FEEDING DURING EXERCISE		5. TYPE OF REPORT & PERIOD COVERED Final - Oct. 1975
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. F. Consolazio		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Nutrition (SGRD-ULN-BE) Letterman Army Institute of Research Presidio of San Francisco, CA 94129		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Work Unit 001, Nutrition Studies in Support of DOD Food Program
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Medical Research and Development Command Washington, DC 20314		12. REPORT DATE 15-18 Oct 1975
		13. NUMBER OF PAGES Thirty-Four (61-94)
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Reprinted from Third International Meeting on "Food for the Armed Forces", U.S. Army Natick Development Center, Natick, MA, 15-18 Oct 1975. Published in Technical Report 76-42-OTD, P. 61-94.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Minimal Requirements, Low Calorie Feeding, Calorie Restriction, Performance and Calorie Restriction

A022 648

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Chronic dieting or under nutrition, as observed during body weight reduction may have other deleterious effects. A combination of water and food restriction makes normal renal function even more difficult since it imposes increased demands for body waste elimination. This could result in a retention of urea and the development of uremia. Body weight loss must be made only at the expense of stored and excessive body fat and not water, since clinical damage (protein catabolism) can also occur.

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Block 20. Abstract

With calorie restriction below 1000 kcalorie/day, body fat and protein must be utilized as energy sources since the maintenance of normal blood carbohydrate levels require a known quantity of protein breakdown. Low antiketogenic diets with adequate mineral intakes can prevent ketosis, minimize protein catabolism, maintain fluid balance and decrease the electrolyte excretions.

Short-term calorie restriction did not reduce performance in the endurance test even when the body glycogen stores should have been depleted. Maximal work capacities were also not impaired.

The best restricted diet (short term 10-12 days) must contain a minimum of 1400 kcalories/day. It should be acceptable, one that the person enjoys eating, and should provide the daily allowances of all the essential vitamins and minerals. The diet must contain a minimum of 100 gm carbohydrate and the daily NRC protein allowances of 0.8 gm/kg body weight.

76-102

(6) THE IMPACT OF LOW CALORIC FEEDING DURING EXERCISE.

(9) Final rept.,

(14) LAIR-76-102

NATO Conference on "Food for the Armed Forces"

October 15-18, 1975

Third International Meeting

ADA022618

U.S. Army Natick Developement Center

Natick, MA

by

(10) C. Frank Consolazio

(11) 1975

(12) 35p.

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Recent emphasis on the mobility of our military forces under conditions where resupply is difficult has created new problems in providing sufficient food and water for combat personnel to maintain adequate performance. The soldier in combat situations for periods up to 10 days must carry his pack, radio equipment, weapons, and an adequate supply of food and water, which is usually quite heavy and bulky. For years the military has been concerned about the minimal food intake necessary for effective maintenance of physical efficiency for varying periods where resupply is impossible.

Complete starvation and calorie restriction have also been utilized by food faddists ("to clean out the body"), by athletes (to make weight in a lower wrestling classification), and by the general population as a means of body weight reduction. These practices are condemned except when under the supervision of a competent physician, because of the "risk factors" that may occur.

Many abnormalities are associated with long-term starvation and semi-starvation. Canadian POW's who had been on restricted intakes in camps in Singapore and Hong Kong during World War II were studied more than 10 years after being released (1). Some of the frequent symptoms observed included easy fatigability, profuse sweating for no apparent reason, numbness and cramps in the calf muscles, loss of ambition, poor vision, edema, dyspnea on even the slightest exertion, depression, tachycardia, anorexia, nausea, restlessness, irritability, and insomnia.

Although marginal nutrition and malnutrition have been known to impair performance, the extent that work capacity and work productivity are altered in the chronically malnourished individual is largely unknown. Relatively few studies have been done on diets ranging between 0 to 2000 kcalories/day,

which have been advocated for weight reduction in obesity. In a number of studies, it has been shown that the addition of well-balanced meals given to malnourished individuals has resulted in an increase in work productivity. Stearns (2) studied Costa Rican natives working on the Pan Am Highway during World War II and showed that their working efficiency and productivity improved greatly with the addition of well-balanced meals. Keller and Kraut (3) reviewed the German World War II data on industrial performance and restricted food intakes and reported that after the food intake of coal miners decreased by 400 kcal in 1946, the coal production per ton was also decreased. The same decrease in food intake also resulted in a decreased work production of steel workers. However, an increase in food allowances of the POW's in Germany resulted in a proportional increase in work production (3).

The long-term calorie restriction study of Keys et al. (4), in young adults demonstrated the detrimental effects that may occur. The consumption of one-half of the daily calorie allowances to maintain body weight resulted in a 25% body weight loss in 26 weeks (Fig. 1). Physical work performance and muscular strength were greatly reduced and did not return to normal until 24 weeks of rehabilitation. Blood hemoglobins and hematocrits were significantly reduced during the restriction period (hemoglobins from 15.1 to 11.7 gm/100 and hematocrits from 46.8 to 36.4% (Table 1)). This suggested that body protein was being catabolized.

Short-term starvation and calorie restriction have also been investigated (5-8). In one study by Henschel et al. (8), four days of fasting resulted in an increase of heart rate and minute volume with a decrease in

mechanical efficiency (8). Physical fitness scores were decreased by 40%. It was suggested that when rapid body weight loss exceeded 10%, deterioration of physical work capacity occurred (due to increased anemias and cardiovascular deficiencies).

As a result of limited information on normal humans, our laboratory conducted three studies on starvation and calorie restriction (for 10 days) to evaluate any metabolic changes that may occur. The experimental designs are shown in Table 2.

In the first study, 6 healthy adult males between the ages of 21 and 52 years starved for 10 days. Water was available ad libitum at all times (5).

In the second study the subjects were 8 young male volunteers who engaged in an intensive physical training program prior to the beginning of the study (6). The study was then divided into 3 phases, a control period of 8 days, a 10-day period of caloric restriction, and an 8-day rehabilitation period. The subjects were randomly divided into 2 groups. Group I received no supplementation and Group II received mineral supplementation. The diet used during the restriction period contained 420 kcal/day of carbohydrate. Energy expenditure was maintained at the 3200 kcal/day level.

In the third study the subjects were again 8 young male volunteers who were assigned to two groups of four men (7). The study consisted of three phases, (a) a control period of 8 days, in which the men consumed 3600 kcal/day, (b) 10 days of caloric restriction on a 500 kcal/day diet containing 85 gm of carbohydrate and 40 gm of protein and (c) 8 days of rehabilitation on a control diet of 3600 kcal/day. Energy expenditures were maintained at the 3600 kcal/day level in the study.

The major problems encountered during 10 days of complete starvation were (a) large body weight losses, (b) highly negative water balances resulting in great body hypohydration, (c) negative nitrogen balances indicating that excessive body protein was being catabolized, (d) marked ketosis, (e) large mineral losses, and (f) abnormal ECG's in all subjects during the experimental phase.

Losses of body water, body protein, and electrolytes have been shown to decrease mental efficiency, morale, ambition and initiative. The marked ketosis observed in this study (5) is attributable to carbohydrate rather than a caloric deficiency. Some studies in the literature have suggested that the undesirable effects of semi-starvation could be reduced or prevented with a low calorie antiketogenic diet (9-11). Gamble (9) demonstrated a sparing effect of glucose upon nitrogen, water and sodium excretion. He observed that ingestion of 100 gm of carbohydrate reduced body protein losses to 50 percent from starvation (from 80 to 40 gm of protein/day), with a subsequent reduction in body water. Bloom (12) reviewed most of this earlier work and concluded that carbohydrate metabolism was intricately involved in the regulation of salt and water metabolism.

As a result the second study was designed to minimize protein catabolism, decrease electrolyte excretion, eliminate ketosis, and maintain water balance by feeding a small quantity of carbohydrate (100 gm) and to observe the effect of mineral supplementation upon these metabolic factors. In this study, although nitrogen balances were not as negative as 10 days of complete starvation, they were still large, indicating that the effects of limited carbohydrate upon reducing protein catabolism was minimal. Mineral supplementation

under these conditions did not affect nitrogen balance (6).

After three days of carbohydrate alone, mineral losses were reduced drastically, showing the rapid adaption to the absence of dietary minerals. Although ECG's were normal in all men, EEG's were abnormal in all men who did not receive mineral supplementation. From the observed data, ketosis was completely eliminated with only 420 kcal/day, and it was apparent that mineral supplementation was very beneficial in sparing water and in maintaining mineral balances and normal EEG patterns. However, protein catabolism was high in both groups suggesting that these low intake levels were inadequate for active individuals, even for short periods of time.

The third study on subjects consuming 500 kcal/day (including 40 gm of protein and 85 gm of carbohydrate) was designed to minimize protein catabolism, maintain water and electrolyte balance and prevent ketosis. This was based on the work of McCracken, et al. (13), who showed that small quantities of dietery protein (40 gm) reduced protein catabolism in several patients receiving 600 kcal/day as carbohydrate. Although body water was again greatly spared in this study, nitrogen balances were again negative, indicating that this was the best balance attainable under these conditions (7).

These three studies are summarized in Fig. 2 body weights, Fig. 3 fluid balance, and Table 3 nitrogen balances.

During complete starvation the total body weight loss average 7.27 kg or 9.5% of the body weight. Within 2 days the average body weight gain was 3.94 kg indicating a large hydration effect. Although the body weight losses in

the 420 kcal/day study were large for both groups during caloric restriction (8% for Group I and 5.9% for Group II), they were less than 9.5% body weight loss observed during complete starvation. In the 500 kcal/day study the body weight losses averaged 8.1 and 7.2% of the initial body weights. These larger body weight losses were due primarily to the fairly high daily expenditure and subsequent calorie deficit that occurred. The body weight losses are more in the range observed by Taylor, et al. (4) whose subjects averaged 7% decrease in body weight on a 580 kcalorie intake of carbohydrate for a 12-day period. Taylor's data indicate some beneficial effect of water retention on a carbohydrate diet alone. In our study, the beneficial effect of mineral supplementation in retaining water was apparent, since Group II lost less body weight than Group I during the caloric restriction period. The beneficial effects of small quantities of carbohydrate in retaining water have also been confirmed by others.

The fluid balances were highly negative during starvation, averaging 318 gm/day for the 10-day period. Hydration was large during the first four days of rehabilitation. This was not unexpected since mineral supplements were not given during starvation and water is closely associated with body glycogen, and body protein. The body hypohydration in the 420 kcal/day study during days 1 and 2 of caloric restriction for Group I is obvious, but these losses were still considerably less than observed during complete starvation, indicating some sparing of water with small quantities of carbohydrate. However, these losses during caloric restriction, were considerably less in Group II, indicating some additional beneficial effects of water retention by mineral supplementation.

In the 500 kcal/day study body water losses were minimal, the greatest water loss being observed in Group I during days 1 to 4 of restriction. The very limited water loss in Group II during restriction is strongly indicative of the beneficial effects of mineral supplementation and the small quantities of carbohydrate and protein being consumed. Rogers et al. (10) have also reported that the supplementation of sodium salts during fasting would reduce ketonuria and hypoglycemia and also minimize body hypohydration as indicated by a lesser weight loss.

The body water loss may have been due to some voluntary hypohydration since the fluid intakes from all sources were decreased during the restriction period; however, other factors such as increased urine volumes and decreased urine specific gravities during caloric restriction do not substantiate this concept. These factors are all indicative of an adequate water supply. Forced ingestion of fluids (10, 13) has not been found to be beneficial in decreasing the hypohydration effect; in fact, it only contributed to an increased urine volume as was observed in our study.

Blood, plasma and red blood cell volumes followed the same hypohydration pattern in both groups being significantly decreased (Fig. 4). Decreases in plasma volumes during starvation are not unusual, having been reported by other investigators (14, 16, 17).

The observation of a decreased plasma volume during fasting is consistent with the negative water balance that occurred. It is the general opinion that during fasting, the extracellular fluid volume is decreased and, as a result, one would expect a proportional decrease in plasma water and an overall decrease in blood volume. Higher osmolalities and the equilibrium of osmotic

pressure would make the concomitant excretion of minerals and body water obligatory. An increase in fluid intake, as was observed, could accommodate the large quantities of minerals and urea being excreted, without causing a negative fluid balance. The decrease in urinary solids, due to decreased urea formation and salt excretion, indicated a reduction in the obligatory loss of water (9, 18) and this prevented ketosis.

Nitrogen balances did not include any estimates of the sweat losses which would have resulted in larger negative balances. THe greatest nitrogen loss occurred during starvation, averaging 8.5 gm of nitrogen/day or 54 gm of protein. In the 420 and 500 kcal/day studies, the nitrogen losses were lower than in complete starvation, indicating that limited carbohydrate and protein, with and without mineral supplementation, did prevent some body catabolism. These differences were not quite as high as the 50 percent reduction reported by Gamble (9) when he compared starvation and an intake of 400 kcalories of carbohydrate. Quinn, et al. (15), also observed no beneficial effect or improvement of negative nitrogen balances on intakes up to 900 kcal/day. Their subjects showed a negative nitrogen balance of 7.3 gm/day for the nine-day study, equivalent to 45.6 gm/protein loss/day.

The great losses of total nitrogen in urine, during caloric restriction, are all indicative of catabolism of body protein for gluconeogenesis and energy. The subsequent decrease of these substances toward the end of the 10-day period, indicate some adaptive mechanisms for conserving body protein. Whether or not these losses of nitrogen are significant in decreasing physical efficiency of the individual is questionable. Some studies have suggested

that the body has labile stores or protein reserves which are readily lost during adaptation to low protein or low calorie diets.

Physical work capacity was measured at these levels, submaximal (3.4 mph on a 4% grade), maximal (3.4 mph with a 1% grade rise/minute, until exhausted) and a stamina test (4.0 or 4.5 mph on a 10% grade for 60 minutes).

Pulmonary ventilations, heart rates, maximal work times and oxygen uptakes in ml/k g/min were essentially unchanged during the entire restriction periods (Table 4, 5, Fig. 5). Since the data suggested abnormalities of hypohydration and protein catabolism, this implies that a sustained caloric deficit would eventually result in a decrease in work capacity as observed in the Keys et al. (4) study. Calorie restriction did not produce a decrease in performance in the stamina test, even when the body glycogen stores should have been depleted.

In the 420 and 500 kcal/day studies the unimpaired performance could be partially attributed to the loss of excessive body fat, the effect of the carbohydrate and mineral supplemented diets, that reduce the body weight and body water losses. These factors acted as a protective mechanism in maintaining maximal efficiency.

Other significant findings during starvation were decreased diastolic pressures which suggest decreased cardiovascular activity, and this appears to be an adaptive mechanism to conserve energy.

The electrocardiograms taken during the last day of fasting were abnormal. The AVF and the QRS axis changes were significantly different from the controls and were considered to reflect the effects of a severe stress. In the Keys, et al. (4) study, the significant changes were also reported in the electrocardiograms. These changes which reached their maximum at 12

weeks of semi-starvation, included "an increase of the QT interval, a continuous decrease in amplitude of all deflections, and marked shifts to the right of the QRS and T axes." As in our study, these changes all returned to normal after rehabilitation.

The data suggest that calorie restriction from 0 to 500 kcal/day should not be recommended due to the significant metabolic and cardiovascular abnormalities that occur.

The field test in Panama was a continuation of the calorie restriction studies. The objectives of this study were to (a) determine the minimal calorie intake that would present unacceptable loss of mental and physical performance of men on maneuvers; (b) obtain some measure of the decrement in performance after various periods (up to 10 days) of reduced caloric intake, and (c) test a compact ration. The laboratory studies were quite adequate for the preliminary observations; however, to evaluate the effects of reduced intake under combat patrol activities, a more realistic environment and military physical activities were utilized. The use of soldiers performing strenuous training maneuvers provided information that was more applicable for making recommendation since a measure of any decrement in performance would provide information to officers regarding the planning of such maneuvers in combat situations.

In this study, four levels of calorie intake were evaluated on troops acclimated to a tropical environment.

The daily food intakes averaged 603, 947, 1362, and 3301 kcal/day for the 10-day restriction period (Table 6). Protein intakes were low for the restricted groups averaging 34.1, 34.7 and 54.4 gm/day for groups I, II and III. The nitrogen deficit exclusive of the sweat losses averaged 3.29 and 2.78 gm/day for groups I and II (or 206 and 174 gm protein for 10 days).

Hemoblobins in the Panama study were essentially unchanged for all groups during the entire experimental phase (Table 7). However, serum proteins were significantly different from controls for Groups I, II and III (the restricted groups) during the same experimental period, suggesting catabolism of body protein. The group consuming a normal diet had serum protein values that were essentially unchanged from control values.

Maximal work capacity measurements included maximal work time in minutes, heart rates and oxygen uptakes in ml/kg/min. These parameters, in general, were not significantly different from control values in all groups (Table 8), suggesting no decrement in performance during the 10-day restrictive period.

The data suggest that daily intakes between 600 to 1400 kcal/day may have been adequate in maintaining physical efficiency during short-term restriction, however, the significant losses of serum protein in the restricted groups suggest that some protein catabolism occurred and this may be detrimental if continued for longer periods of time.

The British Army study in Malaysia in 1970 was designed to reaffirm the 1967 British test that determined that men could maintain military efficiency when fed a suboptimal diet (20). Two dehydrated rations were evaluated — one at a normal daily calorie intake level of 3,500 kcal/day, and the second at a calorie restricted level of 1,800 kcal/day. The primary objective was to evaluate these rations as they would affect the military efficiency of troops during maneuvers in a hot jungle environment. The secondary interest was to evaluate the nutrient losses in sweat under conditions of great water intakes and sweat losses.

Thirty-two young men from the Hong Kong garrison were divided into two groups of 16 men each -- one-half receiving the normal ration (Group I), and the other half receiving the restricted ration (Group II). Three men were hospitalized early in the study and were eliminated. This resulted in Groups I and II having 14 and 15 men, respectively.

The study consisted of a): a 10-day heat acclimatization and training phase in which the men adjusted to the heavy physical activity in the hot, humid Malaysian environment; b) a 3-day control period; c) a 12-day experimental period in which the men bivouacked in the field and ate the experimental ration, and d) a 9-day rehabilitation period.

Food intakes averaged 2974 and 1750 kcal/day for the two groups during the 12-day experimental phase (Table 9). Protein intakes averaged 79.8 and 55.6 gm/day for the same respective groups (1.12 and 0.80 gm/kg body wt). Body weight losses were high, averaging 2.39 and 3.90 kg for Groups I and II respectively. The body weight loss in the normal Group I was apparently due to the unacceptability of the assault ration. The men consumed 500 kcalories less than the 3500 kcalories offered.

Group I nitrogen differences (exclusive of fecal nitrogen losses) were positive averaging a +1.6 gm/day during the entire restriction phase. However, the values for Group II showed the opposite, being negative and averaging a -2.28 gm/day for the entire test phase (Table 10). Although nitrogen intakes were considerably higher for Group I during the experimental period (80 and 56 gm/day of protein), the average urinary nitrogen excretions were not significantly different between groups. There appeared to be no significant decreases

or adaptation in nitrogen excretion with continued calorie restriction of 12 days. However, the daily sweat secretions increased as the experimental period progressed. By days 10-12, the sweat losses increased from 2.10 to 3.17 gm/day for Group I and from 2.51 to 3.01 gm/day for Group II. Although the daily nitrogen intakes of both groups were quite different, the sweat secretions were essentially the same (Table 10).

The blood hemoglobins, hematocrits and serum protein data were not significantly different from control values during the 12-day experimental period (Table 11), and although both groups were in negative water balance during the experimental phase, hemoconcentration was not apparent at 12 days. The greatest portion of the hypohydration occurred within the first 3 experimental days.

Physical work capacity parameters were essentially unchanged from controls for each group and essentially unchanged between groups, suggesting limited effects of short-term calorie restriction on work performance. The data suggested that men could operate adequately on approximately one-half (1750) kcalories under conditions of heavy physical activity with profuse sweating.

SUMMARY

A mild case of calorie deficiency in humans is fairly difficult to diagnose, but the severity of a bad case of calorie deficiency is usually observed by a large body weight and body water loss, the rapidity of the weight loss, and other associated findings of calorie restriction including a negative nitrogen (or protein) balance, an anemia, a low-fasting blood sugar level and a decrease in basal metabolic rate.

Chronic dieting or under nutrition, as observed during body weight reduction may have other deleterious effects. A combination of water and food restriction makes normal renal function even more difficult since it imposes increased demands for body waste elimination. This could result in a retention of urea and the development of uremia. Body weight loss must be made only at the expense of stored and excessive body fat and not water, since clinic damage (protein catabolism) can also occur. For example: during training the initial body weight loss is due to a loss of body fat and the elimination of some tissue fluids. During continual training the process may be reversed since the person may gain body weight due to the increase in body protein or muscle mass.

With calorie restriction below 1000 kcalorie/day, body fat and protein must be utilized as energy sources since the maintenance of normal blood carbohydrate levels require a known quantity of protein breakdown. Low antiketogenic diets with adequate mineral intakes can prevent ketosis, minimize protein catabolism, maintain fluid balance and decrease the electrolyte excretions.

Short-term calorie restriction did not reduce performance in the endurance test even when the body glycogen stores should have been depleted. Maximal work capacities were also not impaired, even though body hypohydration and protein

catabolism occurred during the 10-12 days of restriction. However, a sustained calorie deficit would eventually lead to a decrease in physical work capacity, as in the Keys et al. study (4).

The best restricted diet (short term 10-12 days) must contain a minimum of 1400 kcalories/day. It should be acceptable, one that the person enjoys eating, and should provide the daily allowances of all the essential vitamins and minerals. The diet must contain a minimum of 100 gm carbohydrate and the daily NRC protein allowances of 0.8 gm/kg body weight.

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TABLE 1

LONG-TERM SEMI-STARVATION (KEYS ET AL.)

BIOCHEMICAL ASPECTS*

	Control	Phase Restriction Weeks 12	24	Rehabilitation, Days 6	12
Hemoglobin, g/100	15.1	12.6	11.7	12.3	12.8
Hematocrit, %	46.8		36.4		40.2
Serum Protein, g/100	6.7	6.4	6.0	6.1	6.4
Uric Acid mg/100	3.9		2.8		
Blood Volume, Liters	5.30		5.22		4.80

* Nitrogen intakes averaged 7.8 g/day during restriction, balances were negative by 1.0/day (exclusive of sweat losses).

TABLE 2

CALORIE RESTRICTION STUDIES, 10 DAYS*

EXPERIMENTAL DESIGN

Study I	Starvation, 6 men, Age 21-52 years
	Expenditure 2800-3000 kcal/day
Study II	Restriction 420 kcal/day - All Carbohydrate
	Group I No Supplements - 4 men
	Group II Mineral Supplements 4 men
	Expenditure 3200 kcal/day.
Study III	Restriction 500 kcal/day (85g carbohydrate and 40g protein)
	Group I No Supplements - 4 men
	Group II Mineral Supplements 4 men
	Expenditure 3600 kcal/day

* Water ad libitum in all studies. No vitamin supplements.

TABLE 3

NITROGEN BALANCES, g/MAN/DAY RESTRICTION STUDIES (USAMRNL)*

Phase	Starvation	420 kcal Group I	420 kcal Group II	500 kcal Group I	500 kcal Group II
Control					
6 days, g/day	0	+4.78	+4.51	+1.75	+0.65
Restriction					
Total gm Nitrogen Lost, 10 days	-85.0	-62.0	-60.8	-60.6	-54.9
Rehabilitation					
Total gm retained, 8 days		+43.22	+42.86	+20.82	+24.20

* These balanced do not include sweat losses.
Group II Mineral Supplemented.

TABLE 4

CALORIE RESTRICTION

WORK TIME IN MINUTES (MAXIMAL)

Phase	Starvation	420 kcal.		500 kcal.	
		I	II	I	II
Control	20.8	18.8	20.6	18.8	18.5
Restriction, Days					
1	18.9				
4	20.5			17.2*	17.9
5		18.7	21.6		
7	22.2				
9		17.9	19.9		
10	20.7			17.9	18.9
Rehabilitation	23.4	17.9	20.1	18.4	19.8

* Significantly different from control phase.

Group II Mineral Supplemented.

TABLE 5

CALORIE RESTRICTION

HEART RATES/MIN. MAXIMAL WORK

Phase	Starvation	420 kcal.		500 kcal.	
		I	II	I	II
Control	196	190	194	178	177
Restriction, Days					
1	197				
2		188	190	177	176
4	189				
5		184*	187	176	175
7	186				
8		180*	182*	177	17[illegible]
10	183				
Rehabilitation	177*	180*	182*	178	180

* Significantly different from control phase.

Group II Mineral Supplemented.

TABLE 6

PANAMA - TROPICAL

NUTRIENT INTAKES/DAY*

Nutrients	GROUPS 1	2	3	4
K Calories	603	947	1362	3301
Protein, g.	34.1	34.7	54.4	142.0
Protein g/kg body wt.	0.48	0.48	0.69	2.00
Body weight changes kg. 10 days	-3.22	-2.92	-2.92	-0.57
Nitrogen deficit exclusive of sweat losses g/day	-3.29	-2.78	+0.33	-

* 10 day restriction periods.

TABLE 7

PANAMA - TROPICAL

	GROUP 1	2	3	4
Hemoglobins g/100				
Control	14.8	15.3	15.2	14.5
Day 4	14.7	15.6	15.2	14.8
Day 10	14.8	15.3	14.8	14.6
Serum Proteins G/100				
Control	6.6	6.9	6.3	6.4
Day 4	6.3	6.5	5.8*	6.1
Day 10	6.0*	6.3*	5.6*	6.3

* Values are significantly different from controls.

TABLE 8

PANAMA

MAXIMAL WORK CAPACITY PARAMETERS*

		Phase		
		Restriction		Rehabilitation
	Control	Day 3	Day 9	Day 4
Work Times Min				
I	20.7	19.1	20,8	20.2
II	22.3	20.0	22.7	22.5
III	22.5	20.7	21.3	21.4
IV	22.1	21.2	20.8	21.2
Heart Rates/Min				
I	188	190	192	188
II	188	186	190	191
III	190	189	189	188
IV	194	188	187	184
Oxygen Uptakes, ml/kg/min				
I	43.6	40.4	40.8	40.2**
II	43.7	42.9	43.2	45.2
III	42.8	41.1	40.9**	41.9
IV	42.6	42.2	42.0	41.6

* Balke test, 3.5 mph with grade increased 1%/min. until exhaustion.

** Significantly different from controls at $p<.05$.

TABLE 9

MALAYSIA 1970

NUTRIENT INTAKES/DAY*

	British Assault Ration	Australian Dehydrated
k calories	2974	1750
Protein, g	79.8	55.6
Protein, g/kg Body Weight	1.12	0.80
Fat, g.	107.9	45.4
Carbohydrate, g.	438.0	276.0
Body Weight Changes, kg/12 days	- 2.39	- 3.90

*Mean of 14 mean in each group.

TABLE 10

MALAYSIA: SUMMARY NITROGEN DATA, gm/DAY

	Intake	Output		Difference
		Urine	Sweat	
GROUP I				
Control	16.12	9.81	0.76	+5.55
Restriction Days 1-12 mean/day	12.76	8.47	2.68	+1.61
GROUP II				
Control	14.45	11.66	0.60	+2.19
Restriction Days 1-12 mean/day	8.90	8.40	2.78	-2.28

* These values do not include fecal nitrogen losses.

TABLE 11

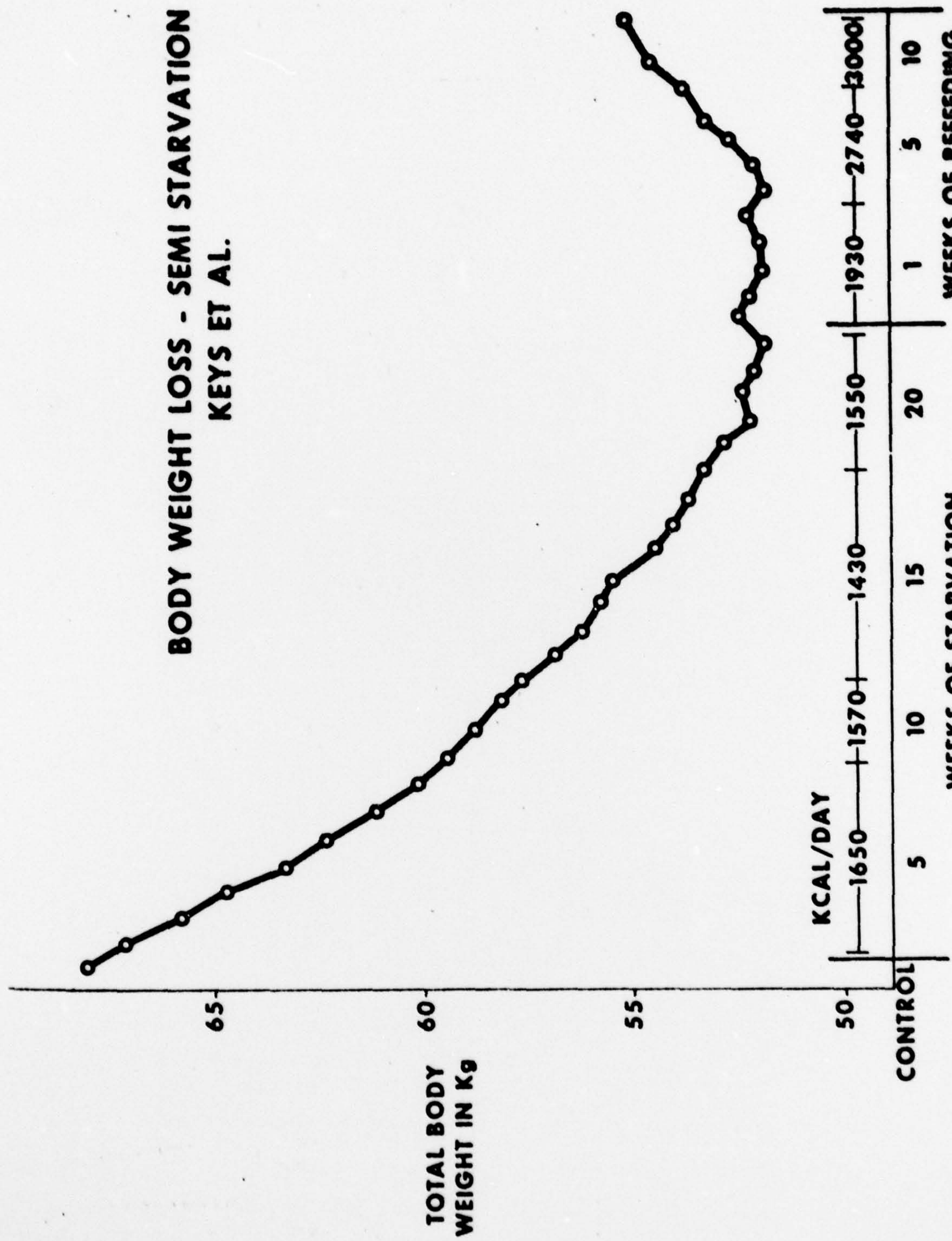
MALAYSIA 1970

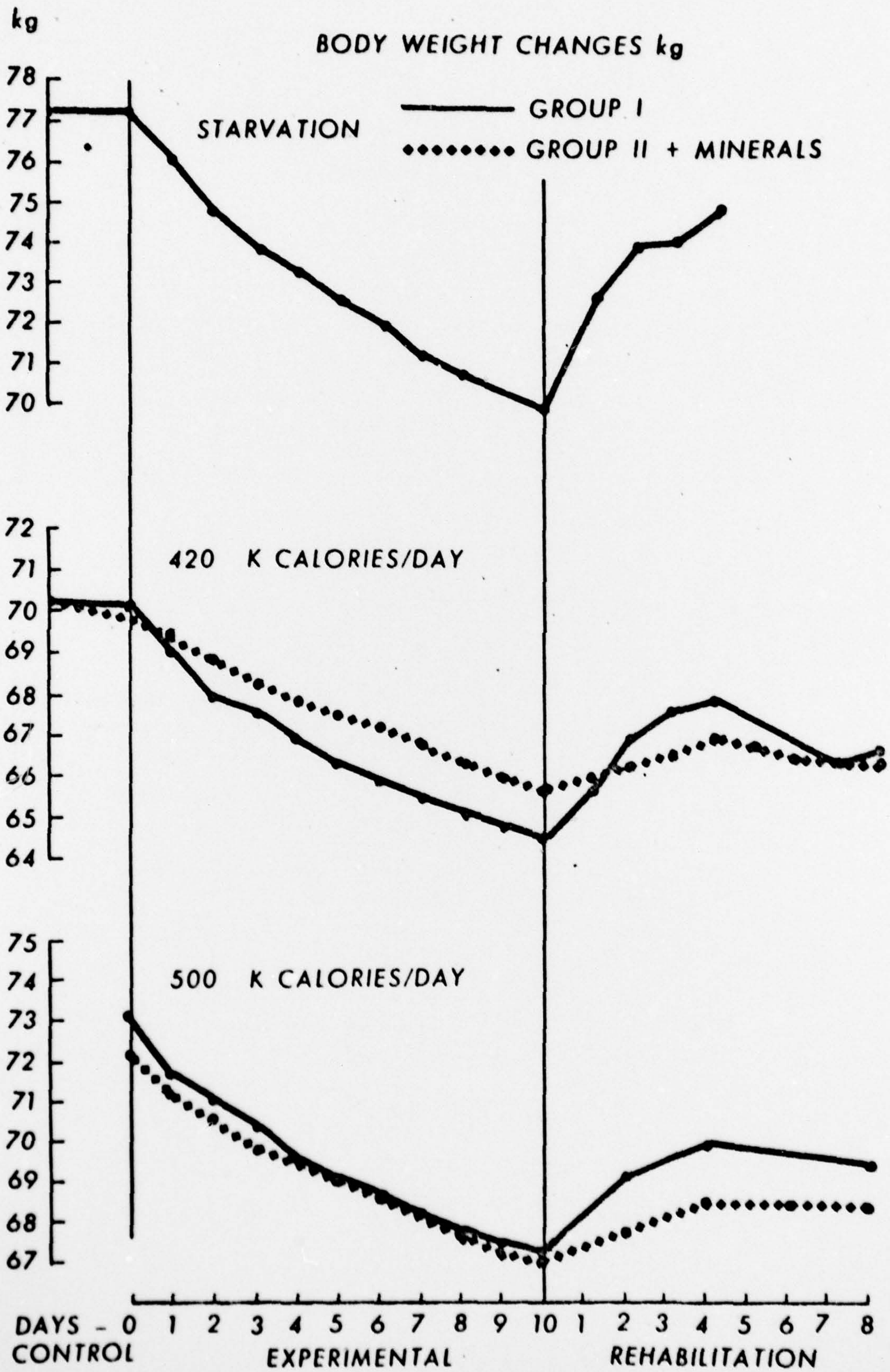
FASTING BLOOD VALUES*

	Group I		Group II	
	Control	Restriction	Control	Restrict
Hemoglobins, g/100	15.3	15.1	14.9	14.9
Hematocrits, %	44.0	43.6	41.1	40.6
Serum Protein, g/100	6.1	6.6	6.4	6.6

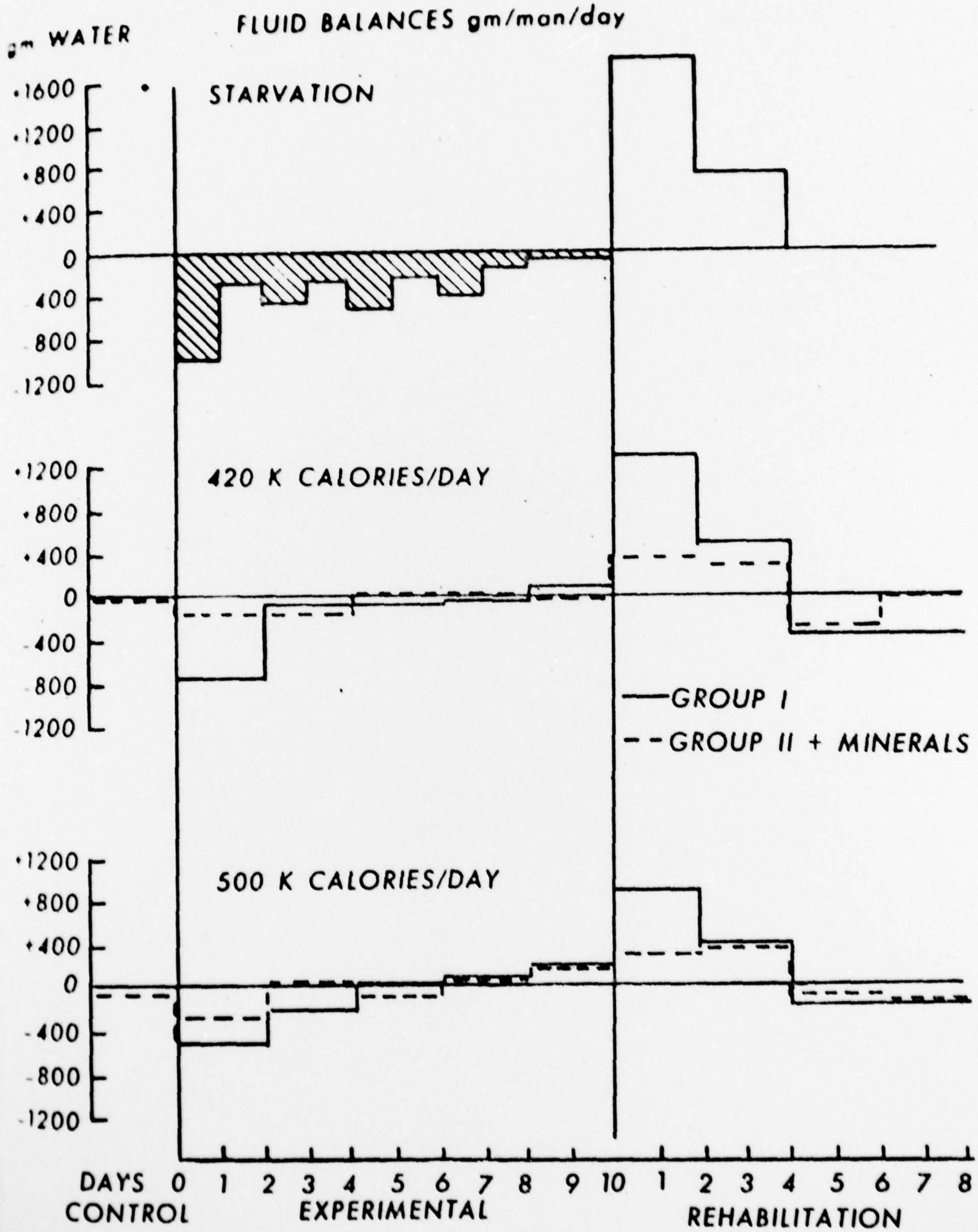
* Twelve (12) days of restriction - values were not significantly different from controls.

strict:
14.9
40.6
6.6

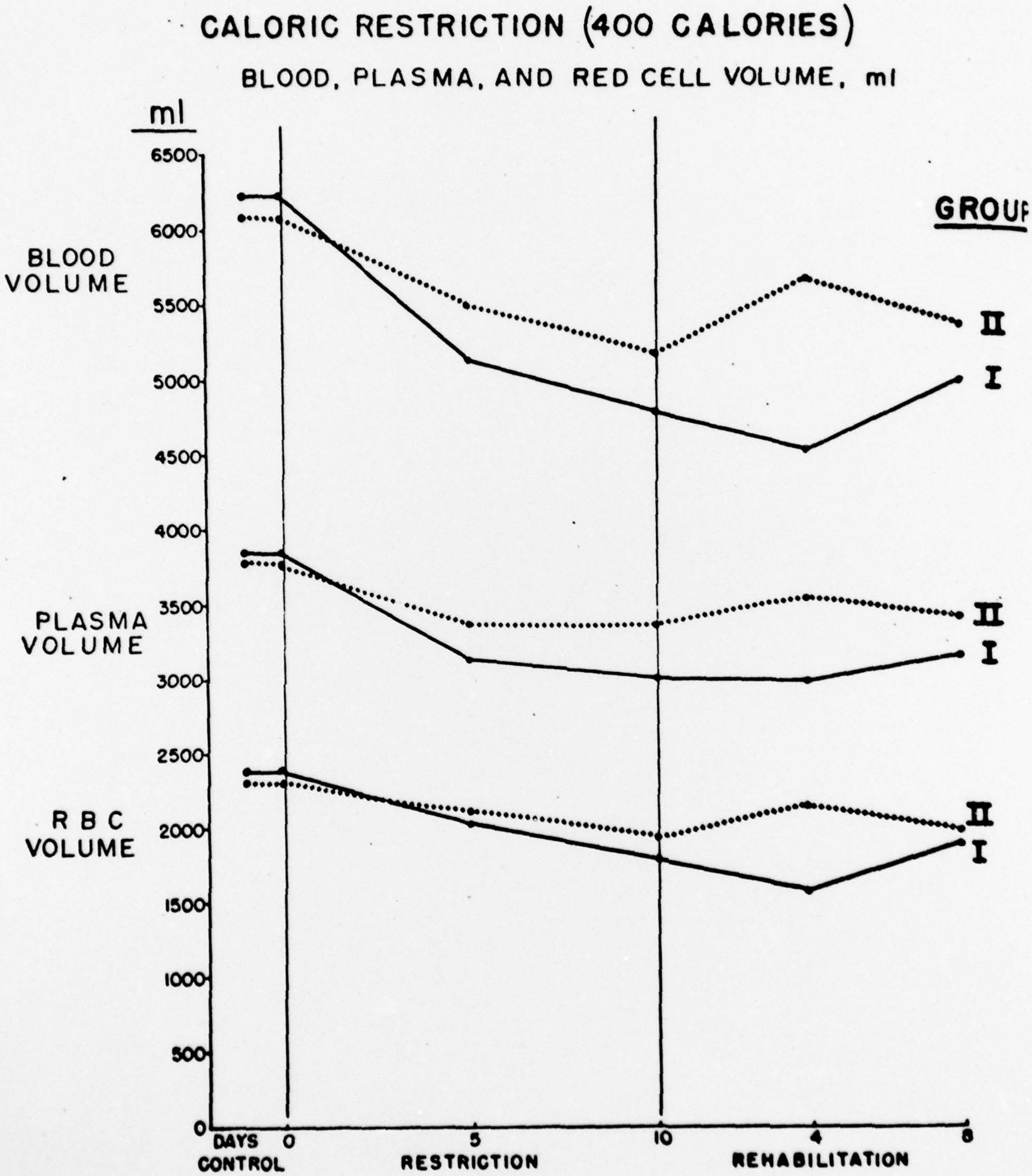


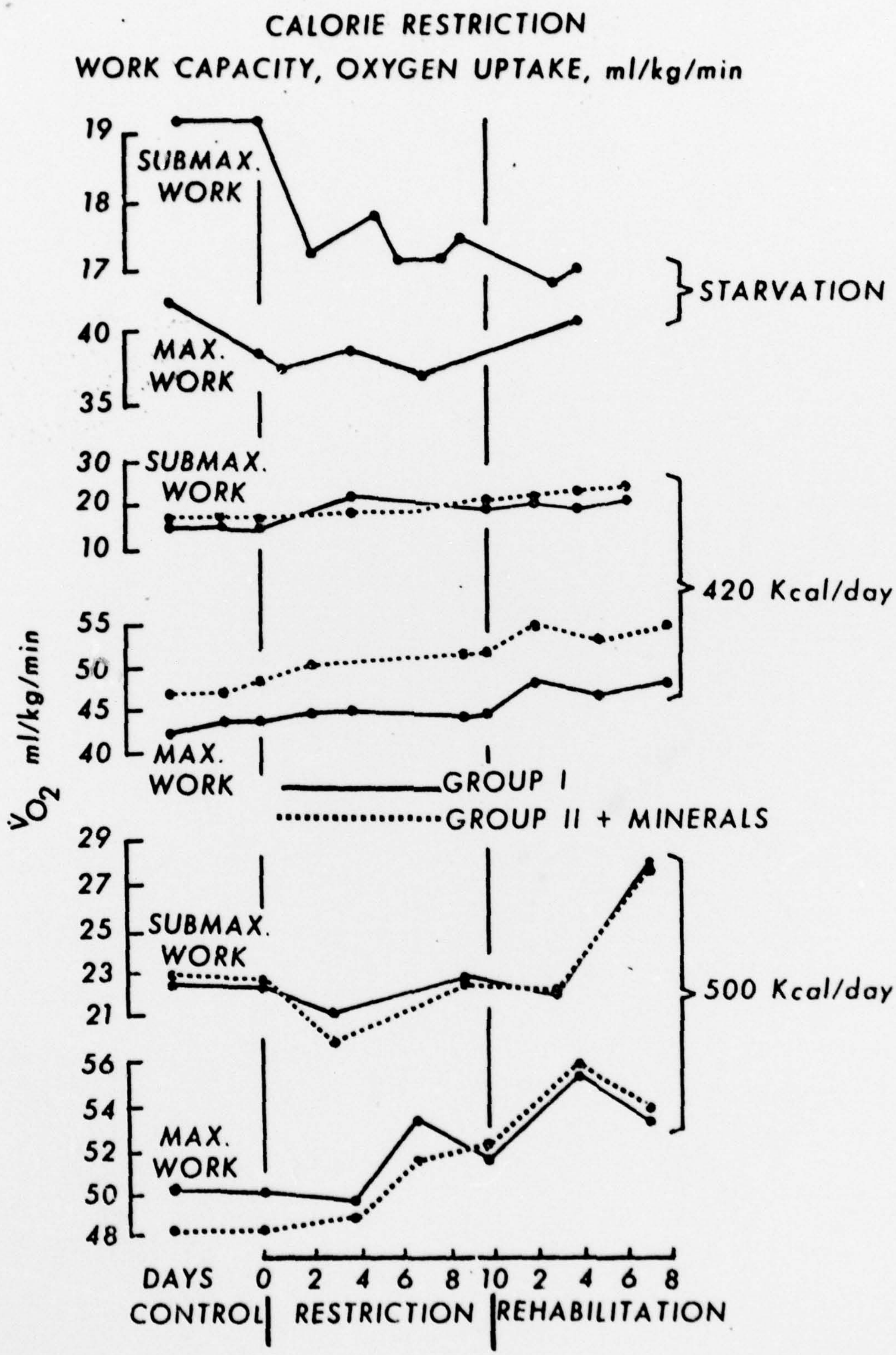


kg
BODY WEIGHT CHANGES kg
GROUP I
GROUP II + MINERALS
STARVATION
78
77
76
75
74
73
72
71
70
420 K CALORIES/DAY
72
71
70
69
68
67
66
65
64
500 K CALORIES/DAY
75
74
73
72
71
70
69
68
67
DAYS - 0 1 2 3 4 5 6 7 8 9 10 1 2 3 4 5 6 7 8
CONTROL
EXPERIMENTAL
REHABILITATION



FLUID BALANCES gm/man/day
gm WATER
STARVATION
+1600
+1200
+800
+400
0
400
800
1200
420 K CALORIES/DAY
500 K CALORIES/DAY
-400
-800
-1200
—GROUP I
--GROUP II + MINERALS
DAYS 0 1 2 3 4 5 6 7 8 9 10 1 2 3 4 5 6 7 8
CONTROL
EXPERIMENTAL
REHABILITATION


CALORIC RESTRICTION (400 CALORIES)
BLOOD, PLASMA, AND RED CELL VOLUME, ml
ml
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
BLOOD VOLUME
PLASMA VOLUME
R B C VOLUME
GROUP
II
I
II
I
II
I
DAYS CONTROL
0
5
10
4
8
RESTRICTION
REHABILITATION


CALORIE RESTRICTION
WORK CAPACITY, OXYGEN UPTAKE, ml/kg/min
SUBMAX. WORK
MAX. WORK
STARVATION
420 Kcal/day
500 Kcal/day
$\dot{V}O_2$ ml/kg/min
GROUP I
GROUP II + MINERALS
DAYS
CONTROL
RESTRICTION
REHABILITATION